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Galaxy evolution as a function of environment and luminosity.

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Galaxy evolution as a function of environment and luminosity.

1.1 Introduction

The properties and evolution of galaxies are strongly dependent on environment (e.g., [1], [9], [10], [12]). In particular, passively evolving spheroids dominate cluster cores, whereas in field regions galaxies are typically both star forming and disc-dominated ([1]).

However, despite much effort it still remains unclear whether these environmental trends are: (i) the direct result of the initial conditions in which the galaxy forms; or (ii) produced later by the direct interact. Lewis et al. ([7]) and Gomez et al. ([3]) that mechanisms such as galaxy harassment or ram-pressure stripping are not important for the evolution of bright galaxies. Instead the strongest candidates for driving their transformation are galaxy suffocation and low-velocity encounters, which are effective in both galaxy groups and cluster infall regions. It is not clear if and how this scenario extends to fainter magnitudes, as there has been observed a strong bimodality in the properties of galaxies about a characteristic stellar mass $\sim 3 \cdot 10^{10} M_{\odot}$ (corresponding to $\sim M^* + 1$; [6]). This bimodality implies fundamental differences in the formation and evolution of giant and dwarf galaxies. To understand the mechanisms underlying the transformation of faint galaxies, we address the relation of galaxy properties with local density and galaxy mass by analysing low redshift galaxies in SDSS-DR4 ([4]) and the core region of the Shapley supercluster ([8], [5]).

1.2 The data

We use a volume-limited sample of about 28000 galaxies taken from SDSS DR4 low-redshift catalogue (LRC) taken from the New York University Value Added Galaxy Catalogue (NYU-VAGC) of Blanton et al. 2005 [2], with $0.005 < z < 0.037$, $\sim 90\%$ complete to $M_r = -18.0$ (see [4] for details). For

the Shapley supercluster, we use data from the ESO Archive, acquired with the ESO/MPI 2.2-m telescope at La Silla. We analysed B- and R-band photometry of eight contiguous fields covering a 2 deg^2 region centred on the Shapley supercluster core (see [8] for details). The galaxy sample is complete to $B = 22.5$ ($>M^*+6$, $N_{\text{gal}} = 16\,588$), and $R = 22.0$ ($>M^*+7$, $N_{\text{gal}} = 28\,008$).

1.3 Results

Analysing SDSS data, we find that the H_α equivalent width, $EW(H_\alpha)$, distribution is strongly bimodal, allowing galaxies to be robustly separated into passively evolving and star-forming populations about a value $EW(H_\alpha) = 2 \text{ \AA}$. Examining the fraction of passively evolving galaxies as a function of both luminosity and local environment, we find that in high-density regions $\sim 70\%$ of galaxies are passively evolving independent of luminosity (see fig. 1 dashed lines). In the rarefied field, where environmental related processes are unlikely to be effective, the fraction of passively evolving galaxies is a strong function of luminosity, dropping from 50% for $M_r = -21$ to zero by $M_r = -18$. Indeed for the lowest luminosity range covered ($-18 < M_r < -16$) none of the ~ 600 galaxies in the lowest-density quartile is passively evolving. The few passively evolving dwarfs in field regions are strongly clustered around bright ($\sim L^*$) galaxies, and throughout the SDSS sample we find no passively evolving dwarf galaxies more than ~ 2 virial radii from a massive halo, whether that be a cluster, group or massive galaxy. Our finding that passively evolving dwarf galaxies are only found within clusters, groups or as satellites to massive galaxies indicates that internal processes or merging are not responsible for terminating star formation in these galaxies. Instead the evolution of dwarf galaxies is primarily driven by the mass of their host halo, probably through the combined effects of tidal forces and ram-pressure stripping.

Moreover the fraction of galaxies with the optical signatures of an active galactic nucleus (AGN) decreases steadily from $\sim 50\%$ at $M_r \sim -21$ to ~ 0 per cent by $M_r \sim -18$ closely mirroring the luminosity dependence of the passive galaxy fraction in low-density environments (see fig. 1 continuous lines). This result reflects the increasing importance of AGN feedback with galaxy mass for their evolution, such that the star formation histories of massive galaxies are primarily determined by their past merger history.

By analysing optical data of the Shapley supercluster we find that the galaxy luminosity function cannot be described by a single Schechter function due to dips apparent at $B \sim 17.5$ ($M_B \sim -19.3$) and $R \sim 17.0$ ($M_R \sim$

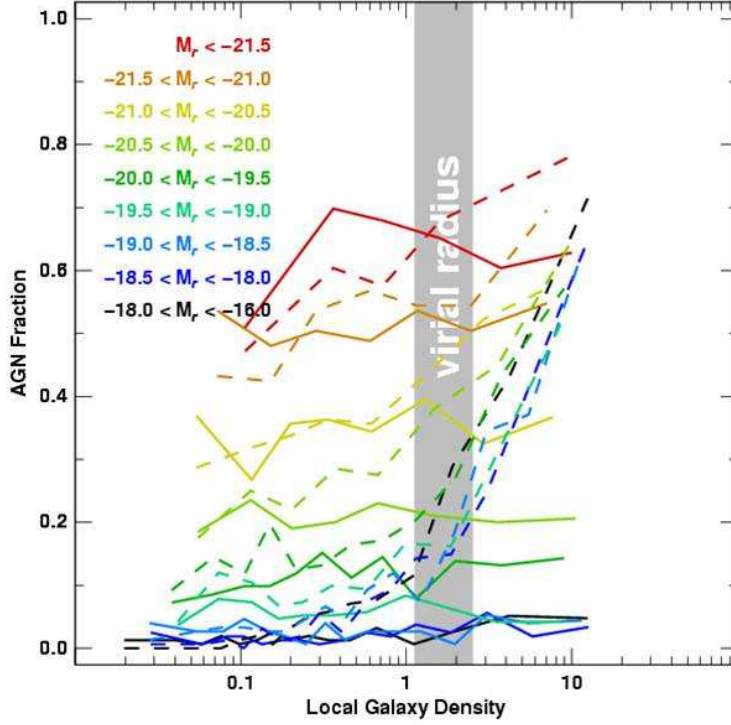


Fig. 1.1. The fraction of passively evolving galaxies (dashed lines) and of AGN classed from their emission line ratios (continuous lines) as a function of both local density and luminosity. Each coloured curve corresponds to a different luminosity bin as indicated. Each density bin contains 150 galaxies. The grey shaded region indicates the typical densities found for galaxies near the virial radius in the Millennium simulation.

- 19.8) and the clear upturn in the counts for galaxies fainter than B and R ~ 18 mag. We find, instead, that the sum of a Gaussian and a Schechter function, for bright and faint galaxies respectively, is a suitable representation of the data. By deriving the galaxy luminosity functions in three regions selected according to the local galaxy density, and find that the LF faint-end is different at more than 3σ confidence level in regions with different densities. These results support the idea that mechanisms related to the cluster environment, such as galaxy harassment or ram-pressure stripping, shape the galaxy LFs by terminating star-formation and producing mass loss in galaxies at $\sim M^* + 2$, a magnitude range where blue late-type spirals used to dominate cluster populations, but are now absent. Moreover the observed B-R colour distribution of supercluster galaxies shows that faint galaxies change from the cluster cores where $\sim 90\%$ of galaxies lie along the

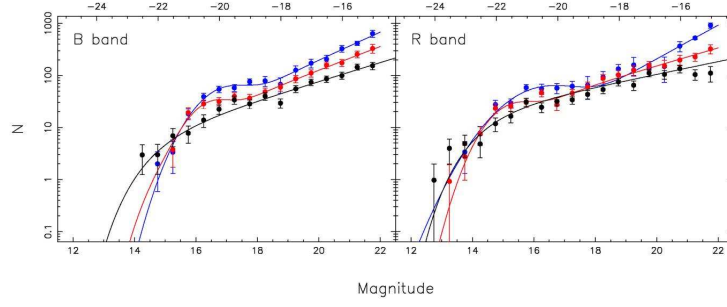


Fig. 1.2. The B- (left panel) and R-band LFs of galaxies in the three regions corresponding to high- (black), intermediate- (red) and low-density (blue) environments. Continuous lines represent the best fit with a Schechter (black) and a Gaussian+Schechter functions. The counts are per half magnitude.

cluster red sequence to the virial radius, where the fraction has dropped to just $\sim 20\%$. This suggests that processes directly related to the supercluster environment are responsible for transforming faint galaxies, rather than galaxy merging. Their location suggests star formation triggered by cluster mergers, in particular the merger of A3562 and the poor cluster SC 1329-313, although they may also represent recent arrivals in the supercluster core complex.

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